Rec'd PCT/PTO 22 JUL 2004

PCT/ZA03/000 1 1

rtifikaat
ENTKANTOOR
REPUBLIC OF SOUTH AFRICA

Certificate
PATENT OFFICE
REPUBLIEK VAN SUID-AFRIKA

ARTEMENT VAN HANDEL
NYWERHEID

DEPARTMENT OF TRADE AND INDUSTRY

ermee word gesertifiseer dat
s is to certify that

RECEIVED
28 JAN 2004
WIPO PCT

the documents annexed hereto are true copies of:

Application forms P.1, P.2 and provisional specification of South African Patent No. **2002/5000** as originally filed in the Republic of South Africa on **21 June 2002** in the name of **TSITSIKAMMA TRUST** for an invention entitled: **"ANALYSER ARRANGEMENTS"**.

Geteken te / Signed at PRETORIA in die Republiek van Suid-Afrika, hierdie / in the Republic of South Africa, this **3rd** dag van / day of **November 2003**

Registrateur van Patente

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

BEST AVAILABLE COPY

FORM P1

REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978

PATENT APPLICATION AND ACKNOWLEDGEMENT

[Section 30(1) - Regulation 22]

The grant of a patent is hereby requested by the undermentioned applicant on the basis of the present application filed in duplicate.

21	01	Official Application No. 2002/5000	DrG Ref.: 606614

71 Full name(s) and address(es) of applicant(s):

Tsitsikamma Trust
Rokewood Avenue
Die Boord
Stellenbosch 7600

R20 R20 R20

54 Title of invention:

ANALYSER ARRANGEMENTS

The applicant claims priority as set out on the accompanying form P2. The earliest priority claimed is:

This application is for a patent of addition to Patent Application No.	21	01	
This application is a fresh application (section 37) based on Application No.	21	01	

THIS APPLICATION IS ACCOMPANIED BY THE FOLLOWING:

- [x] 1. P6 Provisional specification — Pages: 29
- [ ] P7 Complete specification — Pages: — 2 copies
- [x] 2. Drawings — Sheets: 7
- [ ] 3. P8 Publication particulars and abstract in duplicate.
- [ ] 4. Drawing for abstract
- [x] 5. An assignment of invention
- [ ] 6. Certified priority document(s)
- [ ] 7. Copy of Form P2 and SA Patent Application No — 21 01
- [ ] 8. Translation of the priority document(s)
- [ ] 9. An assignment of priority rights
- [x] 10. P3 Declaration and power of attorney on form P3
- [ ] 11. P4 Request for ante-dating on form P4
- [ ] 12. P4 Request for classification on form P9
- [x] 13. P2 Register sheet (in duplicate)

Date: 21 June 2002

DR GERNTHOLTZ INC
PATENT ATTORNEYS OF APPLICANT(S)

74 ADDRESS FOR SERVICE:

DR GERNTHOLTZ INC
PATENT ~~AND TRADE~~ MARK ATTORNEYS
P O BOX 8 CAPE TOWN 8000 SOUTH AFRICA
30 UNION ROAD MILNERTON 7441
TELEPHONE: +27 21 551 2650
TELEFAX: +27 21 551 2960

Received
Official date stamp

Registrar of Patents

(Lodge in Duplicate)

REPUBLIC OF SOUTH AFRIC

REGISTER OF PATENTS

ENTS ACT, 1978

- Official Application No.: 21 01- 2002/5000
- Lodging date: Provisional: 22 2002-06-21
- Acceptance date: 47
- International Classification: 51
- Lodging date: Complete: 22
- Grant date:

Full name(s) of applicant(s)/Patentee(s):

71 Tsitsikamma Trust

Applicants substituted

71

Date registered

Assignee(s):

71

Date registered

Full name(s) of inventor(s)

72 Francois Eberhardt DU PLESSIS

Priority claimed	33	Country	31	Number	32	Date

Title of invention

54 ANALYSER ARRANGEMENTS

Address of applicant(s)/patentee(s)

Rokewood Avenue
Die Boord
Stellenbosch 7600

Address for service

74 Dr GERNTHOLTZ INC (DrG Ref: 606614) Brian Bacon / MJS

30 UNION ROAD
MILNERTON / CAPE
7441

P O BOX 8
CAPE TOWN
8000

TEL: (021) 551 2650
FAX: (021) 551 2960 / 551 2974
E-MAIL: mail@gpa.co.za

Patent of addition No.	74		Date of any change	
Fresh application based on			Date of any change	

FORM P6

REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978

PROVISIONAL SPECIFICATION

[Section 30(1) - Regulation 27]

21	01	Official Application No.: 2002/5000	DrG Ref.: 606614
22		Lodging date: 2002 -06- 21	
71		Full name(s) of applicant(s): Tsitsikamma Trust	
72		Full name(s) of inventor(s) Francois Eberhardt DU PLESSIS	
54		Title of invention ANALYSER ARRANGEMENTS	

ADDRESS FOR SERVICE:
DR GERNTHOLTZ INC
PATENT AND TRADE MARK ATTORNEYS
P O BOX 8 CAPE TOWN 8000 SOUTH AFRICA
30 UNION ROAD MILNERTON 7441
TELEPHONE: +27 21 551 2650
TELEFAX: +27 21 551 2960

DrG REF 606614spec

TITLE OF INVENTION

Analyser arrangements.

FIELD OF INVENTION

The present invention relates to analyser arrangements.

More particularly, the present invention relates to analyser arrangements for spectral analysis of mineral compositions.

BACKGROUND TO INVENTION

In order to manage and control mineral mining operations and processing plants, determination of mineralogical composition of various materials and minerals from in situ state, through the entire process, ending up in final mineral products and plant waste discard, is required. Known methods include grain-counting techniques and laboratory chemical analysis. However, in some cases automation of this process does not produce reliable results and only manual methods prove to be reliable. Furthermore, the determination of elemental chemical composition alone (XRF - X-ray fluorescence spectrography) does not provide all the necessary information. Furthermore, due to the variability in chemical composition it is not possible to utilise this method for the exact description of mineralogical composition. One of the main problems with heavy mineral beneficiation plants is the continuous recycling of material because no real-time or insufficient control is available. Accordingly, automation of the mineral analysis procedure is required.

Furthermore mineral analysis is required for the following:

(a) Determination of the areas of concern for geological surveys, i.e. remote sensing is beneficial to determine the occurrence of surface minerals;

(b) Interpretation of interpret geological surveys, i.e. mineral exploration samples need to be analysed;

(c) Controlling the mining of specific mineral deposits, i.e. mineral samples from the proposed mining area need to be analysed;

(d) Controlling the quality of minerals being mined; i.e. periodically taken samples of the Run-Of-Mine minerals (ROM plant feed) need to be analysed;

(e) Designing, constructing and operating beneficiation plants (mineral processing plants and concentrators), i.e. samples of the expected ROM plant feed material need to be analysed prior to the design and construction thereof; and

(f) Operating mineral processing plants and concentrators, i.e. several operational parameters need to be repeatedly reset and thereby samples are taken from different streams of plant feed conveyed through the plant, final mineral products and plant waste discard, with subsequent analysis of these samples.

It is an object of the invention to disclose analyser arrangements for spectral analysis of mineral compositions.

SUMMARY OF INVENTION

According to the invention, an analyser arrangement for determining the composition of a mineral mixture, includes spectral analysis means for determining the composition of a mineral mixture, and suitable program software operatively associated with the spectral analysis means.

Also, according to the invention, a method of determining the composition of a mineral mixture, includes the steps of

(a) illuminating a mineral mixture to cause light reflection therefrom;

(b) sensing the light reflected by the mineral mixture;

(c) analysing the light reflected by the mineral mixture by spectral analysis to determine the composition of the mineral mixture; and

(d) applying suitable program software operatively associated with steps (b) and/or (c).

The analysis may take place automatically and in real-time.

The mineral mixture may include minerals in situ, minerals conveyed in various ways and forms, such as bulk transport, streams, slurries, temporary or permanent stockpiles, or samples.

The online spectral analysis means may include

(a) illumination means for illuminating the mineral mixture to cause light reflection therefrom;

(b) sensing means for sensing the light reflected by the mineral mixture;

(c) a spectrometer for analysing information supplied by the sensing means, and thereby determining the spectral distribution of the reflected light; and

(d) a data processor for evaluating information supplied by the spectrometer and thereby determining the composition of the mineral mixture.

The spectrometer may be a single beam or a dual beam spectrometer.

The spectral analysis means may include more than one spectrometer.

An additional spectrometer may be included to monitor the illumination of the illumination means.

The program software may be executable computer programme software or embedded binary code programme software.

The illumination means and sensing means may be associated with a probe.

The probe may project partially or fully into the mineral mixture.

The probe may be moved relative to the mineral mixture.

A mechanical shield may be provided to shield the probe from the mineral mixture.

A window encasing may be provided to protect the probe.

The mechanical shield may include scraping means for scraping the surface of the mineral mixture for facilitating internal illumination and sensing of the mineral mixture.

A light shield may be provided to limit external light from influencing the sensing of the sensing means.

The probe may include optical fibres.

The illumination means may include illuminating fibres.

The sensing means may include sensing fibres.

The illumination means may emit UV (ultra-violet), and/or visible and/or IR (infra-red) light.

The processor may identify minerals in the mineral mixture by their spectral identities.

The processor may calculate the quantity of each mineral in the mineral mixture.

The processor may be provided with a graphical user interface.

The processor may be provided with a standard analog or digital industrial communications output.

The analyser arrangement may provide real-time information of the mineral composition.

The analyser arrangement may be provided with operation means for automated control of the operating parameters and settings of a mineral processing plant or parts thereof.

The analyser arrangement may be provided with an additional light source.

The analyser arrangement may be calibrated by setting up an operating procedure.

The operating procedure may include the steps of

(a) off-setting plant operating parameters, which have to be controlled, outside either extremities of optimal required mineral mixture plant settings; and

(b) simultaneously computing operating parameters differences by means of defined analysis set up models and thereby obtaining desired configurations for mineral mixture ranges.

The analyser arrangement may be calibrated manually, semi-automatically or automatically.

The analyser arrangement may also be calibrated by using the results of a bench-top mineral analyser.

Yet further according to the invention, an analyser arrangement for determining the composition of a mineral slurry flow, includes spectral analysis means for determining the composition of a mineral slurry flow, and suitable program software operatively associated with the spectral analysis means.

Yet further according to the invention, a method of determining the composition of a mineral slurry flow, includes the steps of

(a) illuminating a mineral slurry flow to cause light reflection therefrom and/or light transmission therethrough;

(b) sensing the light reflected by and/or transmitted through the mineral slurry flow;

(c) analysing the light reflected by and/or transmitted through the mineral slurry flow by spectral analysis to determine the composition of the mineral slurry flow; and

(d) applying suitable program software operatively associated with steps (b) and/or (c).

The online spectral analysis means may include

(a) illumination means for illuminating the mineral slurry flow to cause light reflection therefrom and/or light transmission therethrough;

(b) sensing means for sensing the light reflected by and/or light transmitted through the mineral slurry flow;

(c) a spectrometer for analysing information supplied by the sensing means, and thereby determining the spectral distribution of the light reflected by and/or transmitted through the mineral slurry flow; and

(d) a data processor for evaluating information supplied by the spectrometer and thereby determining the composition of the mineral slurry flow.

The spectrometer may be a single beam or a dual beam spectrometer.

The spectral analysis means may include more than one spectrometer.

An additional spectrometer may be included to monitor the illumination of the illumination means.

The program software may be executable computer programme software or embedded binary code programme software.

A durable window may be provided to allow the illumination means illuminating the mineral slurry flow and the sensing means for sensing the light.

The illumination means and sensing means may be associated with a probe.

A mechanical shield may be provided to shield the probe from the mineral slurry flow.

The mechanical shield may include a housing for insertion into the mineral slurry flow for facilitating internal illumination and sensing of the mineral slurry flow.

A light shield may be provided to limit external light from influencing the sensing of the sensing means.

The probe may include optical fibres.

The illumination means may include illuminating fibres.

The sensing means may include sensing fibres.

The illumination means may emit UV (ultra-violet), and/or visible and/or IR (infra-red) light.

The processor may identify minerals in the mineral slurry flow by their spectral identities.

The processor may be provided with a graphical user interface.

The processor may be provided with a standard analog or digital industrial communications output.

The processor may calculate the quantity of selected minerals in the mineral slurry flow.

The analyser arrangement may provide real-time information of the mineral composition.

The analyser arrangement may be provided with operation means for automated control of operating parameters and settings of a mineral processing plant or parts thereof.

The analyser arrangement may be provided with an additional light source.

The analyser arrangement may be calibrated by setting up an operating procedure.

The operating procedure may include the steps of -

(a) off-setting plant operating parameters, which have to be controlled, outside either extremities of optimal required mineral mixture plant settings; and

(b) simultaneously computing operating parameters differences by means of defined analysis set up models

and thereby obtaining desired configurations for mineral mixture ranges.

The analyser arrangement may be calibrated manually, semi-automatically or automatically.

The analyser arrangement may also be calibrated by using the results of a bench-top mineral analyser.

Yet further according to the invention, an analyser arrangement for determining the composition of a mineral sample, includes spectral analysis means for determining the composition of a mineral sample whilst being moved.

Yet further according to the invention, an analyser arrangement for determining the composition of a mineral sample, includes

(a) spectral analysis means for determining the composition of a mineral sample;

(b) a probe associated with spectral analysis means;

(c) support means for supporting a mineral sample; and

(d) moving means for moving the mineral sample and the probe relatively to each other.

Also, according to the invention, a method of determining the composition of a mineral sample, includes the steps of

(a) moving a mineral sample;

(b) illuminating the mineral sample to cause light reflection therefrom and/or light transmission therethrough;

(c) sensing the light reflected by and/or transmitted through the mineral sample; and

(d) analysing the light reflected by and/or transmitted through the mineral sample by spectral analysis to determine the composition of the mineral sample.

The spectral analysis means may include

(a) moving means for moving a mineral sample;

(b) illumination means for illuminating the mineral sample to cause light reflection therefrom and/or light transmission therethrough;

(c) sensing means for sensing the light reflected by and/or light transmitted through the mineral sample;

(d) a spectrometer for analysing information supplied by the sensing means, and thereby determining the spectral distribution of the light reflected by and/or transmitted through the mineral sample; and

(e) a data processor for evaluating information supplied by the spectrometer and thereby determining the composition of the mineral sample.

The mineral sample may be wet or dry.

The mineral sample may be moved by rotation and/or pivotation and/or oscillation and/or reciprocation and/or translation.

The spectrometer may be a single beam or a dual beam spectrometer.

The spectral analysis means may include more than one spectrometer.

An additional spectrometer may be included to monitor the illumination of the illumination means.

The illumination means and sensing means may be associated with a probe.

A light shield may be provided to limit external light from influencing the sensing of the sensing means.

The probe may include optical fibres.

The illumination means may include illuminating fibres.

The sensing means may include sensing fibres.

The illumination means may emit UV (ultra-violet), and/or visible and/or IR (infra-red) light.

The processor may identify the spectral identities of minerals in the mineral sample.

The processor may calculate the quantity of each mineral in the mineral sample.

The results of the analyser arrangement may be used for calibrating any other mineral analyser arrangement.

The analyser arrangement may be provided with an additional light source.

The analyser arrangement may be manually, semi-automatically or automatically calibrated.

BRIEF DESCRIPTION OF DRAWINGS

The invention will now be described by way of example with reference to the accompanying schematic drawings.

In the drawings there is shown in:

Figure 1: a perspective view of a first analyser arrangement in accordance with the invention;

Figure 2: a front view of the analyser arrangement seen along arrow II in Figure 1;

Figure 3: a top view of the analyser arrangement seen along arrow III in Figure 1;

Figure 4: a sectional side view of the analyser arrangement seen along arrows IV-IV in Figure 3.

Figure 5: a perspective view of a second analyser arrangement in accordance with the invention;

Figure 6: a sectional end view of the analyser arrangement seen along arrows VI-VI in Figure 5;

Figure 7: a sectional top view of the analyser arrangement seen along arrows VII-VII in Figure 6;

Figure 8: a sectional side view of the analyser arrangement seen along arrows VIII-VIII in Figure 7;

Figure 9: a sectional view of a third analyser arrangement in accordance with the invention.

Figure 10: a perspective view of a fourth analyser arrangement in accordance with the invention;

Figure 11: a front view of the analyser arrangement seen along arrow XI in Figure 10;

Figure 12: a top view of the analyser arrangement seen along arrow XII in Figure 10; and

Figure 13: a sectional side view of the analyser arrangement seen along arrows XIII-XIII in Figure 12.

DETAILED DESCRIPTION OF DRAWINGS

Referring to Figures 1 to 4, a first analyser arrangement for online analysis of a mineral stream in order to determine the composition of the mineral stream, generally indicated by reference numeral 10, is shown.

The first analyser arrangement 10, in use located in proximity of mineral conveying means 12, such as a conveying belt, and conveying a mineral stream 14 to be analysed, includes a probe 16 positioned close to the moving mineral stream 14. The mineral stream 14 in the embodiment example consists of dry minerals.

The probe 16 is provided with two types of optical fibres (not shown), illuminating fibres and sensing fibres. Light emitted by the illuminating fibres is selectively reflected by the minerals in the mineral stream 14, and the reflected light is picked up by the sensing fibres, whereafter information is sent via the probe output 18 to a spectrometer (not shown) which senses the spectral distribution of the light reflected by the minerals in the mineral stream 14, and transmits the output to a data processor

(not shown). The output of the data processor includes seven 4-20 mA signals, each corresponding to a percentage of mineral occurrence.

The first analyser arrangement 10 is associated with software being either an executable computer programme product or an embedded binary code program product.

The light emitted by the illuminating fibres includes visible and NIR (near infra-red) reflected according to the mineral composition and impurities therein. Accordingly, the spectrometer is classified as a visible and NIR spectrometer.

The processor thereafter identifies the digital output or spectral "fingerprints" of the different minerals in the mineral stream 14, and calculates the abundance of each mineral of concern in the mineral stream 14. The processor output may include an operator user-friendly interface or an industry standard analog or digital communications output.

Furthermore, the first analyser arrangement 10 is provided with an additional light source 20 for illuminating the mineral stream 14.

Also, the first analyser arrangement 10 is provided with a mechanical shield 22 to shield the probe 16 from the mineral stream 14, i.e. for scraping the surface of the mineral stream 14 to enable the probe 16 to internally illuminate the mineral stream 14.

Calibration of the analyser arrangement may be achieved by means of a bench-top analyser model where meaningful changes in the mineralogy of the mineral stream 14 occurs.

The implementation of the analyser arrangement is achieved in various phases, namely:

(a) Calibration phase;

(b) Optional desktop analyser arrangement; and

(c) ON-line analyser arrangement.

During the calibration phase, a representative set of mineral samples is obtained by the user. The number of known samples required at this stage is $n=(m+1)^2$, where n is the number of samples, and m is the number of mineral mixtures to be differentiated. The accuracy of the composition of these samples determines the final accuracy of the analyser arrangement according to the invention. An analysis and training set for the specific set of minerals is performed, and an expected level of accuracy is calculated.

During the desktop analyser arrangement phase, a desktop analyser, set up according to the results of the calibration phase, is constructed and includes:

- An industrial computer preloaded with analysis, calibration and data storage software,
- At least one spectrometer,
- At least one light source, and
- At least one probe assembly.

Initially, the system is provided with rough calibration and tuning, however final tuning has to be performed over a time span, for example four to eight weeks, in order to achieve full accuracy.

The spectral data of several samples and the known values for these samples are determined and thereafter utilised for obtaining final tuning parameters, to be loaded in the bench top model calibration files.

Finally, during the on-line analyser arrangement phase, the on-line analyser arrangement in accordance with the invention is constructed.

Accordingly, the first analyser arrangement 10 in accordance with the invention provides an arrangement and method to achieve accurate and frequent measurements of mineral streams in mineral processing operations. The on-line analyser arrangement provides mineral concentrator operations with real-time information of the mineral composition of mineral streams and provides the option of automatic plant settings and automated control or otherwise the option of frequent and timely manual control of plant settings.

Referring to Figures 5 to 8, a second analyser arrangement for online analysis of a mineral slurry flow in order to determine the composition of the mineral slurry flow, generally indicated by reference numeral 24, is shown.

The second analyser arrangement 24, in use located in proximity of mineral conveying means 26, such as a pipe, conduit, or chute, and conveying a mineral slurry flow 28 to be analysed, includes a probe 30 positioned within the moving mineral slurry flow 28.

The probe 30 is provided with two types of optical fibres (not shown), illuminating fibres and sensing fibres. Light emitted by the illuminating fibres is selectively reflected by the minerals in the mineral slurry flow 28, and the reflected light is picked up by the sensing fibres, whereafter

information is sent via the probe output 32 to a spectrometer (not shown) which senses the spectral distribution of the light reflected by the minerals in the mineral slurry flow 28, and transmits the digital output to a data processor (not shown). The data processor output includes seven 4-20 mA signals, each corresponding to a percentage of mineral occurrence.

The second analyser arrangement 24 is associated with software being either an executable computer programme product or an embedded binary code program product.

The light emitted by the illuminating fibres include visible and NIR (near infra-red) reflected from the slurry flow according to the mineral composition and impurities therein. Accordingly, the spectrometer is classified as a visible and NIR spectrometer.

The processor thereafter identifies the digital output or spectral "fingerprints" of the different minerals in the mineral slurry flow 28, and calculates the abundance of each mineral of concern in the mineral 28. The processor output may include an operator user-friendly interface or an industry standard analog or digital communications output.

Also, the second analyser arrangement 24 is provided with a protective housing 34 to shield the probe 30 from the mineral slurry flow 28. The protective housing 34 is provided with a transparent window 36, angled at 45° towards the oncoming slurry. The transparent window 36 is made of saphire.

Calibration of the analyser arrangement may be achieved by means of a bench-top analyser model where meaningful changes in the mineralogy of the mineral slurry flow 28 occurs.

The implementation of the analyser arrangement is achieved in various phases, namely:

(a) Calibration phase;

(b) Optional desktop analyser arrangement; and

(c) ON-line analyser arrangement.

During the calibration phase, a representative set of mineral samples is obtained by the user. The number of known samples required at this stage is $n=(m+1)^2$, where n is the number of samples, and m is the number of mineral mixtures to be differentiated. The accuracy of the composition of these samples determines the final accuracy of the analyser arrangement according to the invention. An analysis and training set for the specific set of minerals is performed, and an expected level of accuracy is calculated.

During the desktop analyser arrangement phase, a desktop analyser, set up according to the results of the calibration phase, is constructed and includes:

- An industrial computer preloaded with analysis and data storage software,
- At least one spectrometer,
- At least one light source, and
- At least one probe assembly.

Initially, the system is provided with rough calibration and tuning, however final tuning has to be performed over a time span, for example four to eight weeks, in order to achieve full accuracy.

The spectral data of several samples and the known values for these samples are determined and thereafter utilised for obtaining final tuning parameters, to be loaded in the bench top model.

Finally, during the on-line analyser arrangement phase, the on-line analyser arrangement in accordance with the invention is constructed.

Accordingly, the second analyser arrangement 24 in accordance with the invention provides an arrangement and method to achieve accurate and frequent measurements of mineral slurry flows in mineral processing operations. The on-line analyser arrangement provides mineral concentrator operations with real-time information of the mineral composition of mineral slurry flows and provides the option of automatic plant settings and automated control or otherwise the option of frequent and timely manual control of plant settings.

Referring to Figure 9, a third analyser arrangement for static analysis of a mineral sample in order to determine the composition of the mineral sample, generally indicated by reference numeral 38, is shown.

The third analyser arrangement 38, includes a cylindrical housing 40 having a base 42 and a lid 44. The cylindrical housing 40 is made of aluminium, the base 42 is constructed of mild steel and the lid 44 is constructed of PVC (polyvinyl chloride). The third analyser arrangement 38 is provided with a motor 46 for rotating a holder 48. A modified test-tube 50 containing the mineral sample 52 to be analysed is removably located in the holder 48. The third analyser arrangement 38 furthermore includes a probe 54 connected to a spectrometer (not shown) and surrounded by a plug 56 adapted to fit in the housing 40 and a light source (not shown). The third analyser arrangement 38 is associated with

an industrial computer (not shown) preloaded with analysis and data storage software. The third analyser arrangement 38 may be provided with additional spectrometers and light sources.

By means of rotating the holder 48, a greater extent of mineral surface of the mineral sample 52 being read and analysed resulting in greater accuracy and consistency and minimising the effects of random specular reflectance from mineral crystal surfaces.

In addition, the third mineral spectral analyser 38 can be constructed to be semi-automatically calibrated when a single beam spectrometer is provided and automatically calibrated if a dual beam spectrometer or two single beam spectrometers are provided.

The probe 54 is provided with two types of optical fibres (not shown), illuminating fibres and sensing fibres. Light emitted by the illuminating fibres is selectively reflected by the minerals in the mineral sample 52, and the reflected light is picked up by the sensing fibres, whereafter information is sent via an output to a spectrometer (not shown) which senses the spectral distribution of the light reflected by the minerals in the mineral sample 52, and transmits the digital output to a computer (not shown). The computer provides its output in both graphical user interface and in data files which is written to non-volatile storage such as a hard disc.

The light emitted by the illuminating fibres include visible and NIR (near infra-red) reflected from the mineral sample 52 according to the mineral composition and impurities therein. Accordingly, the spectrometer is classified as a visible and NIR spectrometer.

The processor thereafter identifies the digital output or spectral "fingerprints" of the different minerals in the mineral sample 52, and calculates the abundance of each mineral of concern in the mineral sample 52. The computer output may include an operator user-friendly interface.

The third analyser arrangement 38 is associated with software being either an executable computer programme product. The software may be semi-automated or fully automated depending on the type of calibration.

Thus the third analyser arrangement 38, also known as a bench-top spectral mineral analyser or rotating mineral sampler, is utilised for analysing several mineral samples by means of the spectrometer while the motor 46 rotates the holder 48 and thus also rotates the modified test tube 50 containing the mineral sample 52. The data of the analysed mineral samples is used for calibration and tuning of parameters of the software of the first mineral analyser arrangement 10 and the second mineral analyser arrangement 24 as well as frequent adjustment of operational plant parameters.

Referring to Figures 10 to 13, a fourth analyser arrangement for online analysis of a mineral stream in order to determine the composition of the mineral stream, generally indicated by reference numeral 58, is shown.

The fourth analyser arrangement 58, in use located in proximity of mineral conveying means 60, such as a conveying belt, and conveying a mineral stream 62 to be analysed, includes a probe 64 projecting into the moving mineral stream 62. The mineral stream 62 in the embodiment example consists of dry minerals.

The probe 64 is provided with two types of optical fibres (not shown), illuminating fibres and sensing fibres. Light emitted by the illuminating fibres is selectively reflected by the minerals in the mineral stream 62, and the reflected light is picked up by the sensing fibres, whereafter information is sent via the probe output 66 to a spectrometer (not shown) which senses the spectral distribution of the light reflected by the minerals in the mineral stream 62, and transmits the output to a data processor (not shown). The output of the data processor includes seven 4-20 mA signals, each corresponding to a percentage of mineral occurrence.

The fourth analyser arrangement 58 is associated with software being either an executable computer programme product or an embedded binary code program product.

The light emitted by the illuminating fibres includes visible and NIR (near infra-red) reflected according to the mineral composition and impurities therein. Accordingly, the spectrometer is classified as a visible and NIR spectrometer.

The processor thereafter identifies the digital output or spectral "fingerprints" of the different minerals in the mineral stream 62, and calculates the abundance of each mineral of concern in the mineral stream 62. The processor output may include an operator user-friendly interface or an industry standard analog or .digital communications output.

The fourth analyser arrangement 58 is provided with or without a window encasing 68 to shield the probe 64 from the mineral stream 62, and enabling the probe 64 to internally illuminate the mineral stream 62.

Calibration of the analyser arrangement may be achieved by means of a bench-top analyser model where meaningful changes in the mineralogy of the mineral stream 62 occurs.

The implementation of the analyser arrangement is achieved in various phases, namely:

(a) Calibration phase;

(b) Optional desktop analyser arrangement; and

(c) ON-line analyser arrangement.

During the calibration phase, a representative set of mineral samples is obtained by the user. The number of known samples required at this stage is $n=(m+1)^2$, where n is the number of samples, and m is the number of mineral mixtures to be differentiated. The accuracy of the composition of these samples determines the final accuracy of the analyser arrangement according to the invention. An analysis and training set for the specific set of minerals is performed, and an expected level of accuracy is calculated.

During the desktop analyser arrangement phase, a desktop analyser, set up according to the results of the calibration phase, is constructed and includes:

- An industrial computer preloaded with analysis, calibration and data storage software,
- At least one spectrometer,
- At least one light source, and
- At least one probe assembly.

Initially, the system is provided with rough calibration and tuning, however final tuning has to be performed over a time span, for example four to eight weeks, in order to achieve full accuracy.

The spectral data of several samples and the known values for these samples are determined and thereafter utilised for obtaining final tuning parameters, to be loaded in the bench top model calibration files.

Finally, during the on-line analyser arrangement phase, the on-line analyser arrangement in accordance with the invention is constructed.

Accordingly, the fourth analyser arrangement 58 in accordance with the invention provides an arrangement and method to achieve accurate and frequent measurements of mineral streams in mineral processing operations. The on-line analyser arrangement provides mineral concentrator operations with real-time information of the mineral composition of mineral streams and provides the option of automatic plant settings and automatic control or otherwise the option of frequent and timely manual control of plant settings resulting in improved beneficiation.

Date: 21 June 2002

DR R O P GERNTHOLTZ
Dr GERNTHOLTZ
Patent Attorneys of Applicants
P O Box 8 CAPE TOWN 8000
30 Union Road MILNERTON/CAPE
SOUTH AFRICA
Tel: (021) 551 2650
Telefax: (021) 551 2960
DrG Ref: 606614
606614spec

LIST OF REFERENCE NUMERALS

10 First analyser arrangement

12 Mineral conveying means

14 Mineral stream

16 Probe

18 Probe output

20 Light source

22 Mechanical shield

24 Second analyser arrangement

26 Mineral conveying means

28 Mineral slurry flow

30 Probe

32 Probe output

34 Protective housing

36 Transparent window

38 Third analyser arrangement

40 Cylindrical housing

42 Base

44 Lid

46 Motor

48 Holder

50 Modified test tube

52 Mineral sample

54 Probe

56 Plug

58 Fourth analyser arrangement

60 Mineral conveying means

62 Mineral stream

64 Probe

66 Probe output

68 Window encasing

TSITSIKAMMA TRUST

NO OF SHEETS 7
SHEET NO 1
DRG Ref.: 606614

FIG. 1

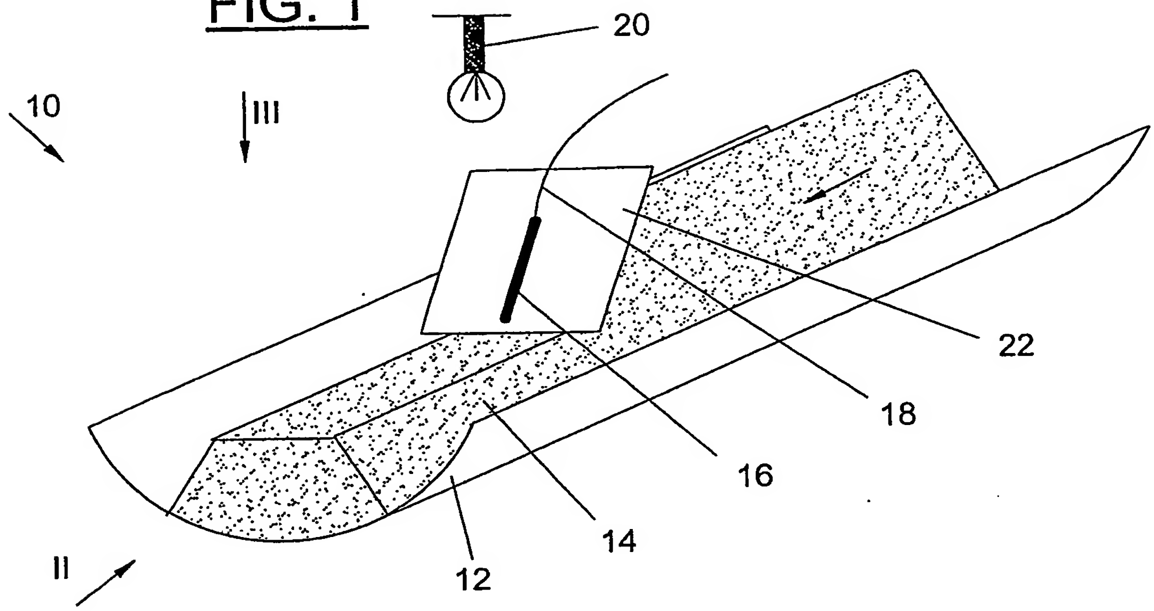
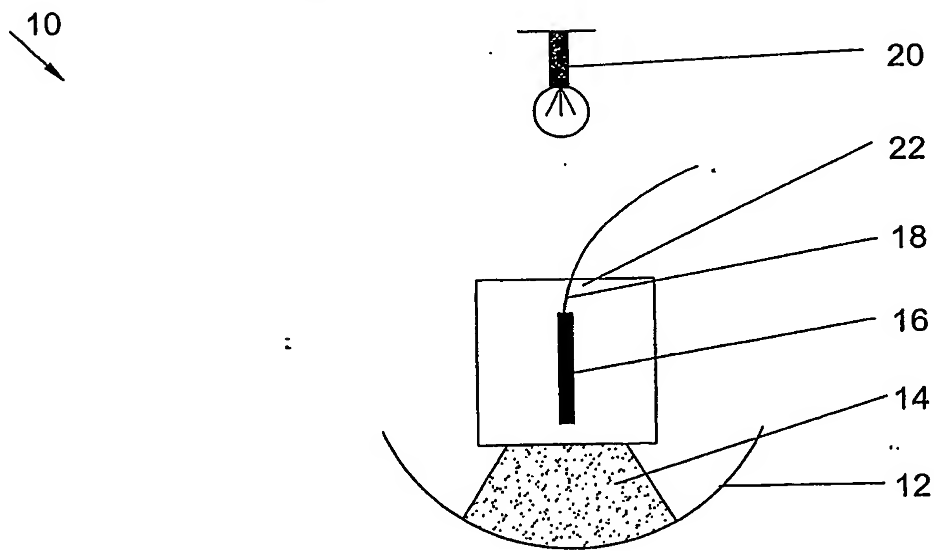


FIG. 2



DR GERNTHOLTZ INC, Box 8, Cape Town 8000, Patent Attorneys of Applicant(s)

2002/5000

TSITSIKAMMA TRUST

NO OF SHEETS 7
SHEET NO 2
DRG Ref.: 606614

FIG. 3

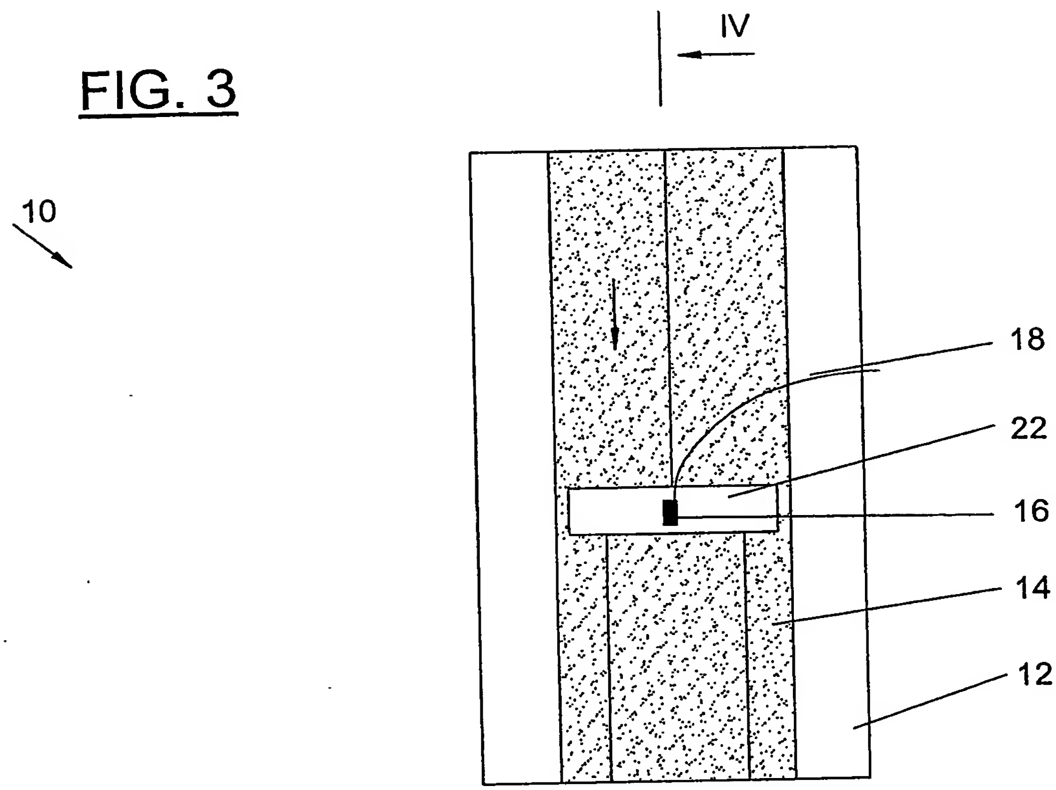
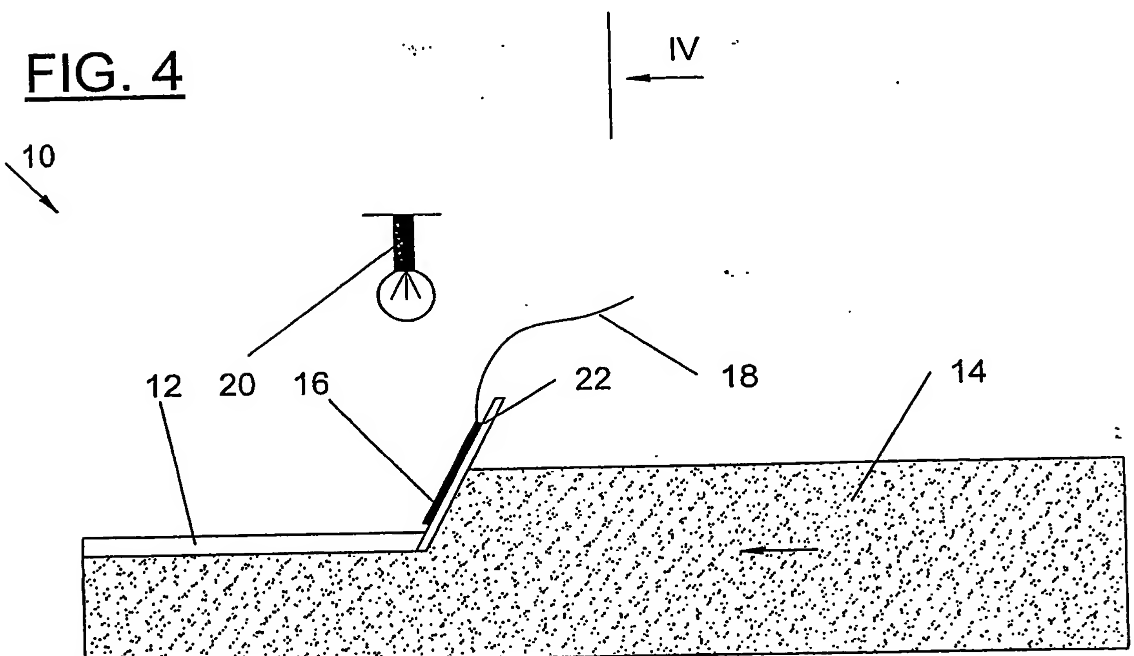


FIG. 4



DR GERNTHOLTZ INC, Box 8, Cape Town 8000, Patent Attorneys of Applicant(s)

TSITSIKAMMA TRUST

FIG. 5

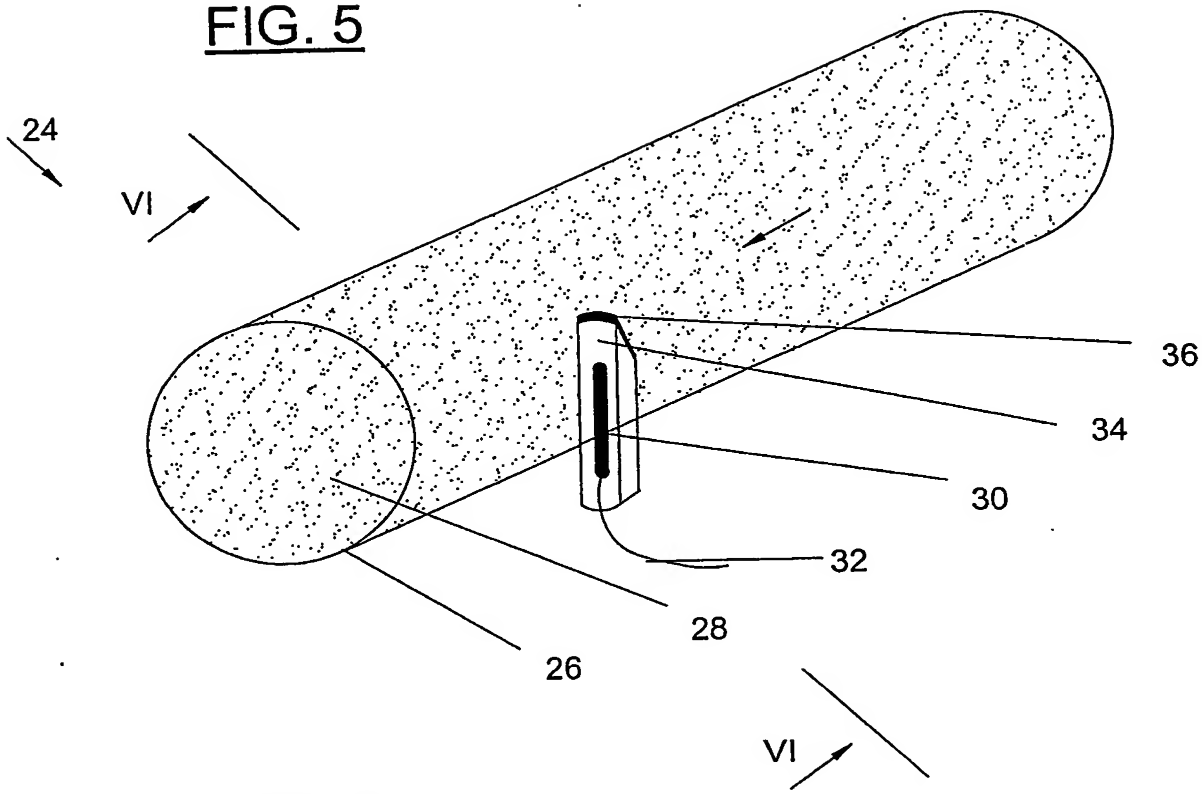


FIG. 6

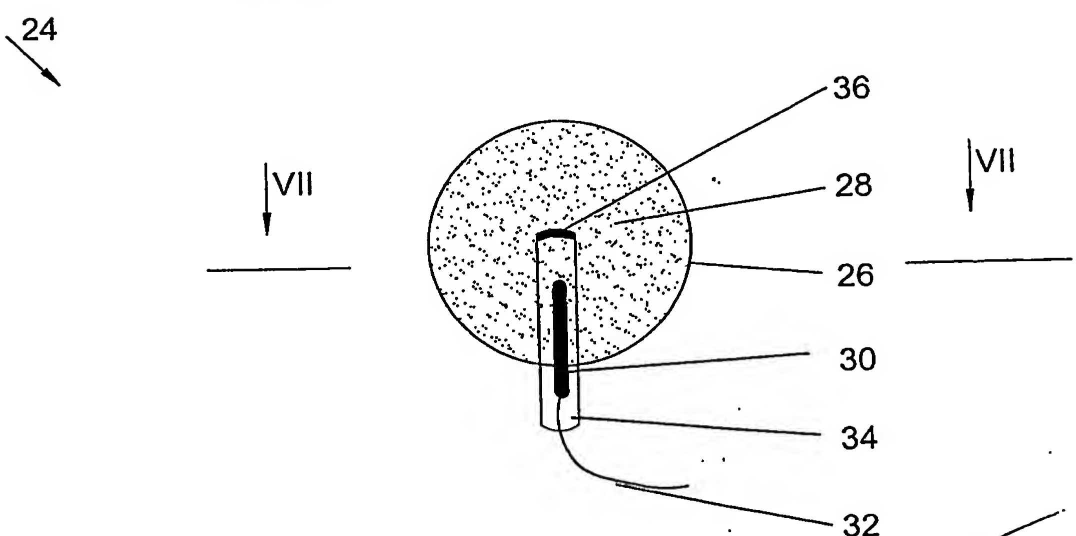


FIG. 7

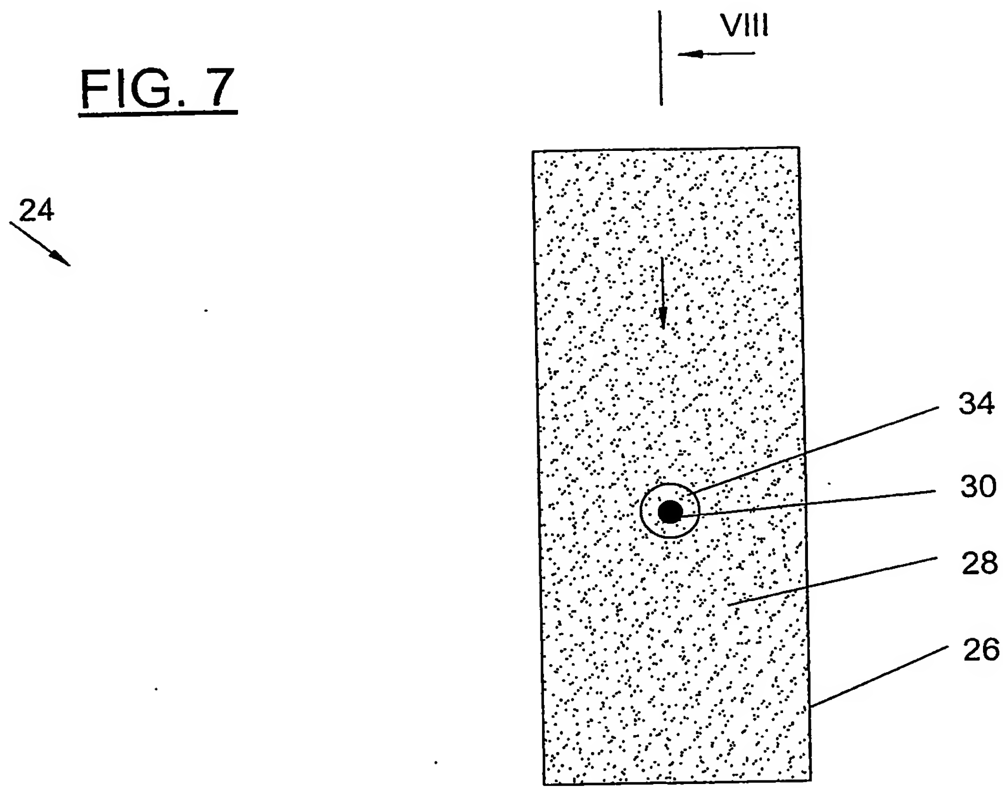


FIG. 8

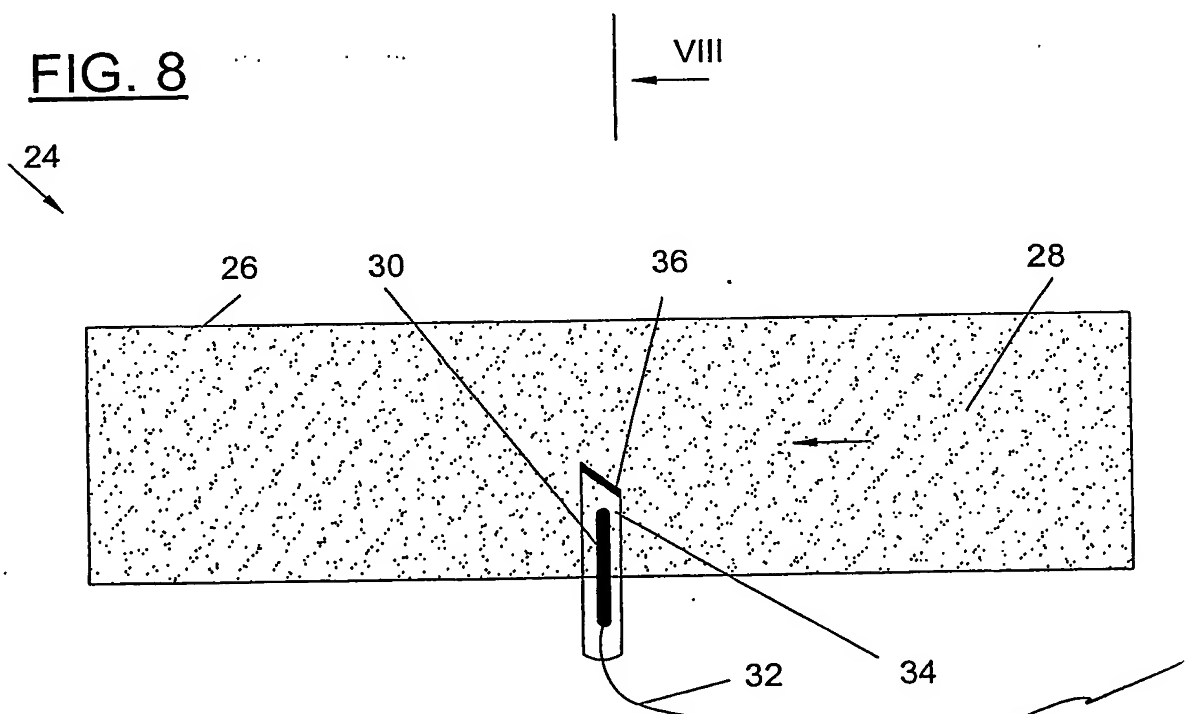


FIG. 9

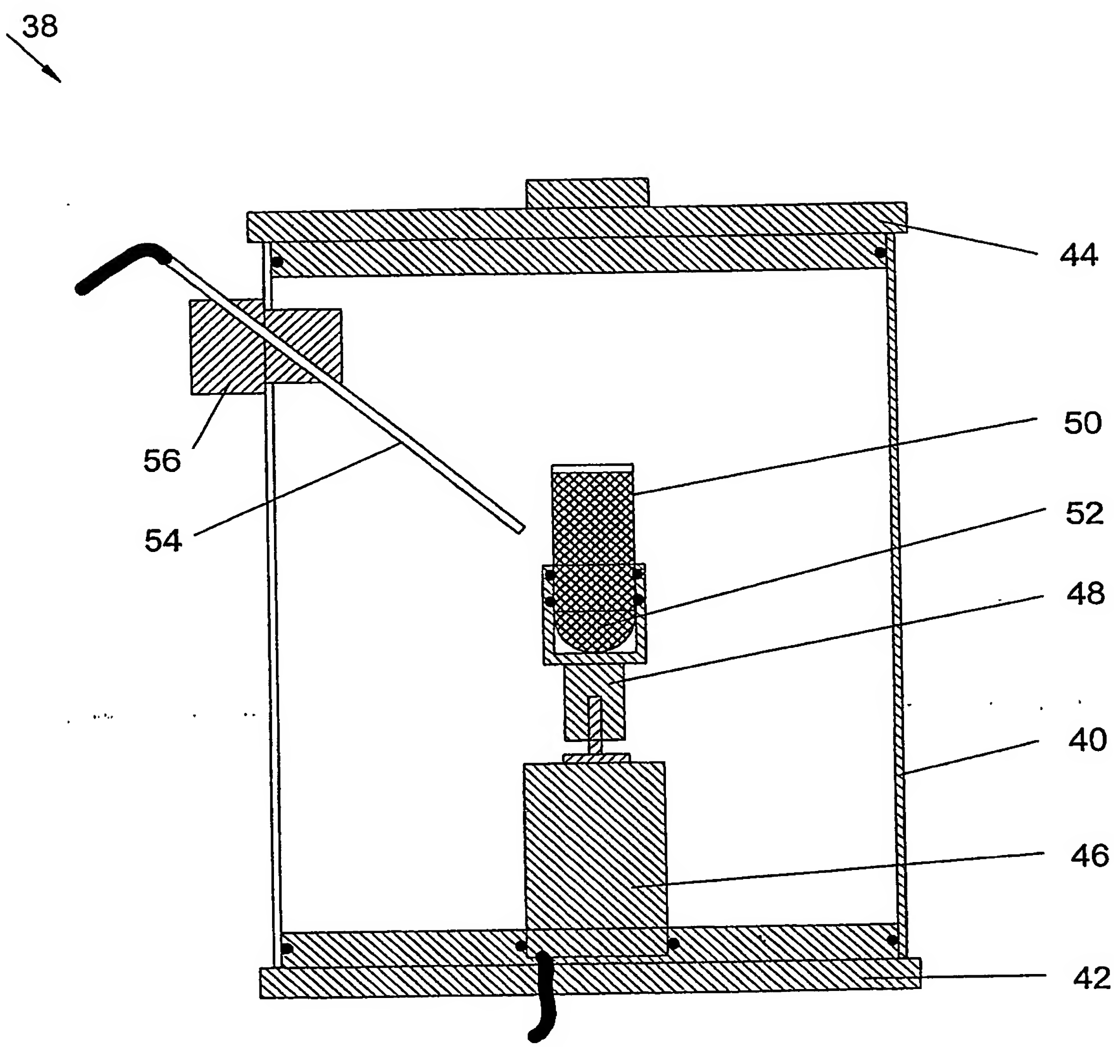


FIG. 10

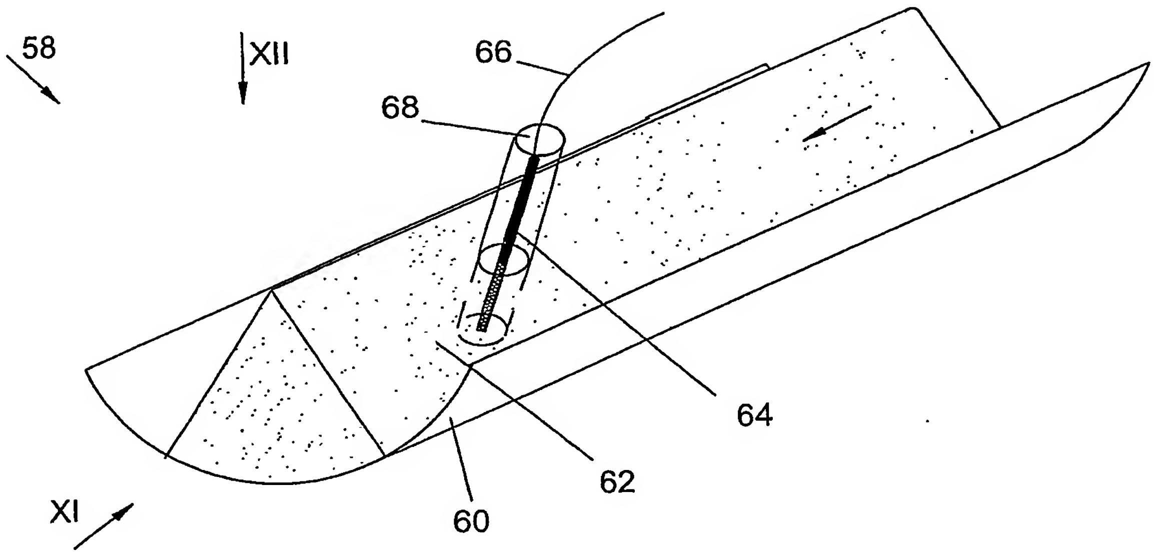


FIG. 11

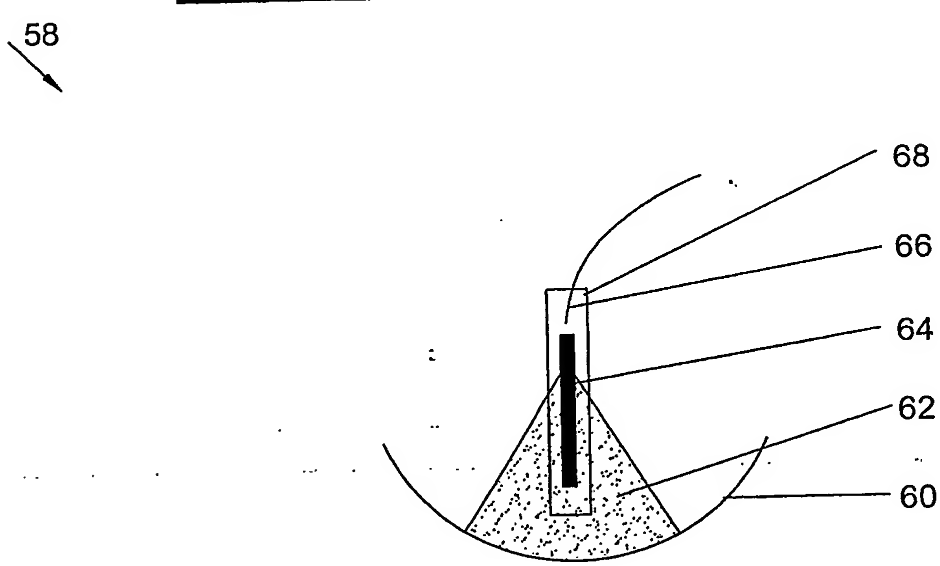


FIG. 12

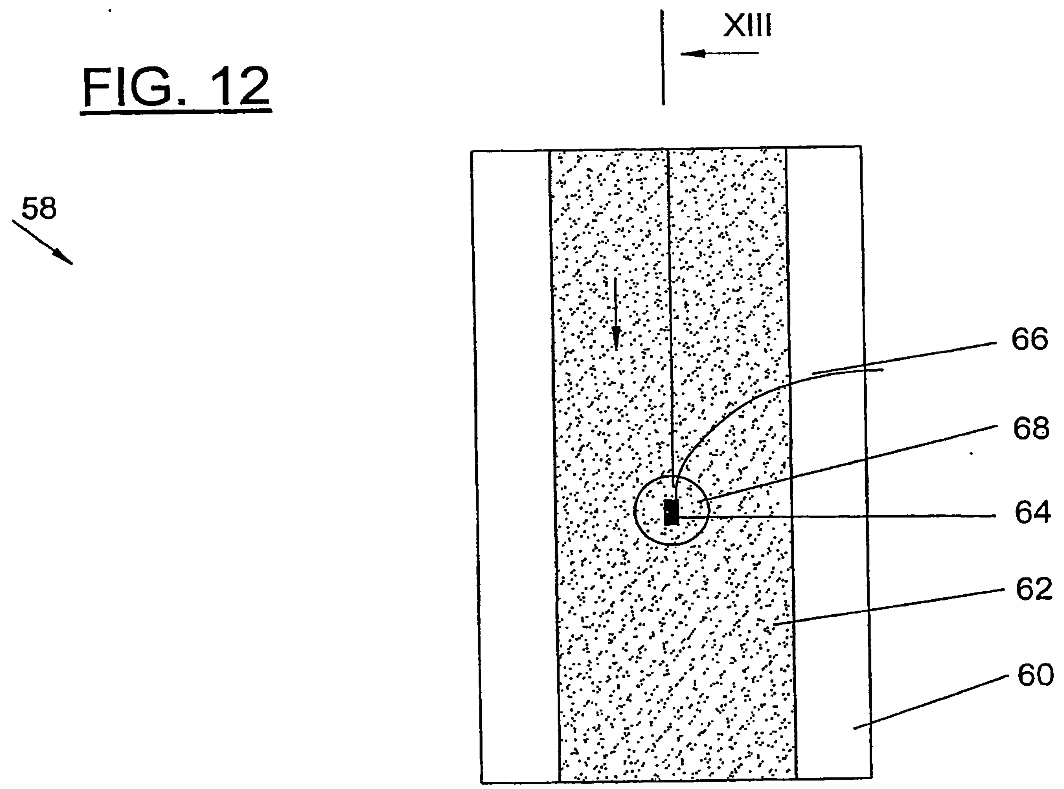


FIG. 13